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Original
Micromechanics-based multiscale modelling for nonlinear analysis of fibre-reinforced composites using DIGIMAT / Kaleel, I.; Petrolo, M.; Carrera, E.; Giugno, M.; Linari, M.. - ELETTRONICO. - (2018). (Intervento presentato al convegno First International Conference on Mechanics of Advanced Materials and Structures (ICMAMS) tenutosi a Torino nel 17-20 June 2018) [10.5281/zenodo.1308076].

Availability:
This version is available at: 11583/2710638 since: 2018-07-10T08:49:25Z

Publisher:
Erasmo Carrera, JN Reddy

Published
DOI:10.5281/zenodo.1308076

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05 May 2023

ICMAMS 2018
First International Conference on Mechanics of Advanced Materials and Structures
Turin, 17-20 June 2018
www.icmams.com

Micromechanics-based multiscale modeling for nonlinear analysis of fiber-reinforced composites using DIGIMAT

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The research work presents numerical investigations on nonlinear mechanics, damage and failure behavior for a class of composite materials and structures through micromechanics-based multiscale analysis. A computational framework based on DIGIMAT and MSC NASTRAN is utilized to model the problem in hand [1]. At the microscale, various constituents of the microstructure (fiber, inclusions, cavities, etc.) are modeled as a representative volume element (RVE). Two approaches are utilized to address the virtual material characterization and scale transition, namely, the direct finite element analysis (FEA) and mean field homogenization technique (MFH). The former method provides a detailed and accurate description of the micro field, but may lead to very high computational overheads from a macroscopic structural perspective. The latter is based on a semi-analytical method (Self-consistent, Mori-Tanaka and Double Inclusion) accompanied by great computational efficiency with lower details on local distributions due to volume averaging. Nonlinearity within the microstructure constituents is modeled through a class of nonlinear models such as the elasto-plastic damage model (Lemaitre-Chaboche model [2]). The study shall address how the aforementioned approaches prove efficient and accurate in the prediction of composite materials and structures response across different scales, from micro (investigating the effect of defects, local distributions, singularities) to macro (with the structural analysis of a composite panel). Numerical predictions are validated against existing numerical and experimental results from literature.

References

[1] MSC Software Company. Digimat User's Manual. E-xtream Engineering, 2018.

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